

ATTACHMENT 2

DESIGN VERIFICATION

FOR

**PROCUREMENT OF 40 FT LOW-FLOOR
BATTERY ELECTRIC BUSES**

SPECIFICATION NO. VE21-054



Massachusetts Bay Transportation Authority
Vehicle Engineering
Boston, Massachusetts

A) General

The Authority may direct the Contractor to demonstrate, by physical test, conformance to any requirement in the specification. Test reports, that demonstrate full compliance on identical configuration components, may be submitted by the Contractor for Authority review and consideration for acceptance.

B) Test Program Plan:

The Test Program Plan is used as a means for the Contractor to demonstrate Specification compliance to the Authority. The Contractor's Test Program Plan shall identify all inspection and test points; component and system tests; and shall include a schedule for all tests and inspections. The Contractor shall submit their Test Program for approval consideration during the Initial Design Review meeting. (RFP Section 10; and Technical Specification CDR 22).

C) Pilot Bus Design and Qualification Tests

Pilot Bus Design Qualification Tests are to be conducted to demonstrate compliance with the design requirements at operating and environmental extremes. These tests are to be conducted on production components, assemblies, subsystems, and the Pilot bus. The tests shall be done on the first level of assembly which will demonstrate design compliance. Qualification tests are limited to the number of units needed to prove design compliance.

The Contractor may submit prior qualification test reports conducted on comparable buses. Those test reports shall be reviewed, and at the Authority's discretion may elect to waive test(s) as appropriate.

Although the Contractor is required to perform any and all tests in order to qualify the design, at a minimum the Authority requires the following qualification tests to be performed:

- 1) Performance test: To be performed on the pilot bus to demonstrate compliance to Section TS 7.
 - a) Top speed test per TS 7.1
 - b) Gradeability test per TS 7.2
 - c) Acceleration test per TS 7.3
 - d) Jerk rate per TS 7.4
 - e) Operating range per TS 7.5
 - f) Energy Economy per TS 7.6
- 2) Structural tests shall be performed on the bus structure to prove compliance to TS 13.2
 - a) Shaker table test shall be performed by the Contractor per TS 13.2
 - b) Strain gauge testing with bus loaded to gross load per TS 13.2
- 3) Noise and vibration tests: To be performed on the pilot bus to prove compliance to TS 5.8
- 4) Jacking test: To be performed on the pilot bus to prove compliance to TS 19
- 5) Clearance test: To be performed on the pilot bus to prove compliance to TS 6.5, 6.6, and 6.7
- 6) Bus height test: To be performed on the pilot bus to prove compliance to TS 6.3
- 7) Aisle width and accessibility tests shall be performed on the pilot bus to prove compliance to TS 6.9, 68.8, and 71.3
- 8) Passenger seat tests shall be performed on a test rig prior to the pilot bus to prove compliance to TS 68.10
- 9) Vehicle climate room test shall be performed on the pilot bus to demonstrate that the temperature schedule outlined in TS Section X is maintained by the HVAC system for the specified climactic extremes.
- 10) Boarding ramp cycle test shall be performed on a test rig to demonstrate 10,000 continuous, trouble-free cycles of the activate-deploy-stow function and 1,000 continuous, trouble-free cycles

of the ramp obstruction detection function. The test rig shall simulate the vehicle ramp installation in all respects. Any observed failure will nullify the test, and the test shall be re-run completely after the fault has been corrected

- 11) Passenger door operational test shall be performed on the pilot bus. The Contractor shall demonstrate zero failures per 100,000 continuous, door cycles. Any observed failure will nullify the test, and the test shall be re-run completely after the fault has been corrected
- 12) Door force test shall be performed on the pilot bus to demonstrate compliance to TS 70.8 and 70.8.1
- 13) Lighting intensity test shall be performed on the pilot bus to demonstrate compliance to TS 65.1
- 14) Fire Detection test shall be performed on the pilot bus to demonstrate compliance to TS 5.10
- 15) Multiplex System test shall be performed on the pilot bus to demonstrate compliance to TS 36 and 75
- 16) Watertightness test shall be performed on the pilot bus(s) and all production buses. This water test shall replicate the pressure and direction of water flow seen during operation and cleaning with the bus wash equipment in use at the Authority. The Water Test Inspection checks the integrity of the vehicle's body seams, window frame seals, entrance and exit doors, windows, and any other exterior component close-out, for their ability to keep rainwater, road splash, melting snow and slush, and other exterior water, from entering the inside of the vehicle or any sealed compartment. The vehicle's interior and sealed compartments shall be inspected for signs of moisture and water leaks. If any moisture or water is detected, then the source of the leak will be located and repaired by the Contractor, and the vehicle will be tested again.
- 17) Safe Minimum Sound test shall be performed on the pilot bus to demonstrate compliance to TS 8.2
- 18) Electromagnetic Interference test shall be performed on the pilot bus to demonstrate compliance to Section TS 5.2.3, TS 33, TS 77, TS Attachment 4.
- 19) Mobile CCTV tests shall be performed to demonstrate compliance to TS Attachment 3
- 20) Communications Equipment tests shall be performed to demonstrate compliance to TS Attachment 4
- 21) Mobile Radio tests shall be performed to demonstrate compliance to TS Attachment 6
- 22) Fare Collection and Validation system tests shall be performed to demonstrate compliance to TS Attachment 7
- 23) Performance brake testing shall be performed on the pilot bus to demonstrate system efficiency and balance. Testing shall be performed by the Contractor using a roller type PBBT
- 24) Brake stopping tests shall be performed on all buses per TS 29.7

In addition to tests performed on the Pilot bus, proof of concept shall also be required for any new or improved item, any exercised option, and as part of a submission for 'approved equal' status. Proof of concept shall be provided for Climate Room Test, Boarding Ramp Cycle Test, Passenger Door Test, and Structure.

D) Test Reports:

No later than one (1) month after successful completion of each test, a report shall be provided by the Contractor which summarizes the test results, analyses, and corrective actions. Reports shall include photographs, charts, and additional data to support the test results. Reports must include a statement that certifies conformance to specified requirements. Should the Authority find the data submitted not to be acceptable, the Contractor shall complete the tests as directed by the Authority with no increase in contract cost or extension of the delivery schedule. Notations of the successful completion of each test shall be included in the appropriate Bus History Book (RFP Section 10.20).

E) First Article Inspection (FAI)

The Authority's project team shall conduct the FAI on the entire pilot bus. This will be the first opportunity the Authority will have to see all components / sub-assemblies installed, and a serviceability review can be conducted.

The FAI permits the Technical Project manager to see, in three dimensions, what could be seen only on two-dimensional drawings up to that point. If the First Article Inspection is of a component that the Contractor is purchasing, rather than making itself, the First Article Inspection discloses details that were not visible beforehand. The First Article inspection is usually the first point at which maintainability of the component can be evaluated, inasmuch as it is the first point at which relationships between elements can be appreciated. The Technical Project Manager may approve the design that is revealed at the First Article Inspection, or may require changes in order that the component can meet the requirements of the Contract.

It is also used to establish the quality level of workmanship that will be maintained for the balance of the components. The level is established by the Technical Project Manager.

The FAI shall include visual and measured inspections, total bus operation, and water test. In addition, the pilot bus will be instrumented for a 15-mile road test to record time, speed, acceleration, engine torque, and engine speed. Equipment used for these measurements and recordings shall be turned over to the Authority when pilot bus testing is complete. All test equipment shall be new with valid certificates of calibration. During the FAI, the Contractor shall mockup locations of all decals and placards for Authority review and approval. When the locations are approved by the Authority, the Contractor shall permanently install, accurately measure, and document, the Authority approved location of all decals and placards. The Contractor shall provide a copy of the decal installation document to the Authority no later than two weeks after the FAI.

The Contractor shall assume that the Authority shall subject all initial components of the bus to first article examination and acceptance to include physical examination, acceptance, and commercial testing of, and acceptance by the Authority of an initial part, major assembly, subassembly, system, subsystem, apparatus or material, manufactured or assembled by either the Contractor or Subcontractors. At the Authority's request, all sub-suppliers involved in open or critical design issues shall be on site to provide appropriate engineering and technical support at the pilot bus FAI.

F) Pilot Bus Tests at the Authority

The pilot bus shall undergo additional testing in order to verify that the requirements of this Specification are being met.

Upon delivery of the pilot bus, the bus will be tested at the Authority for no less than two months. Pilot bus tests at the Authority will include visual and measured inspections and simulated revenue service on a route(s) chosen by the Authority. The pilot bus may be instrumented and loaded with weights to simulate a passenger loading consistent with the vehicle's Gross Load. While instrumented and loaded, the pilot bus will be tested by the Authority to verify that the performance requirements in this Specification are being achieved. Interfaces with Authority-provided equipment, including ITS and radio systems, will also be tested at this time. The Authority will conditionally approve the pilot bus after it has successfully passed an Authority audit of its conformance with the specified configuration and has successfully completed the pilot testing activities.

G) Post Delivery Evaluation and Monitoring Test Program

The Contractor shall instrument the Pilot Bus and five (5) serial production buses for the following:

- 1) Energy Economy Optimization per TS 7.7
- 2) Post Delivery Performance Monitoring per TS 7.8

H) Drawing and Data Approval Process:

The following classification will be used by the Authority during the design review and approval process:

- 1) Approved. The Technical Project Manager concurs with the information in its submitted form. The act of approval by the Authority means that the Contractor may proceed with the procurement of materials and components and with fabrication. It does not imply that the design is adequate, or dimensions are correct, and it does not relieve the Contractor of responsibility to comply with all requirements of the Specification.
- 2) Conditionally Approved. The Technical Project Manager conditionally agrees with the submitted information. Additional information may need to be provided to allow a complete review, or details may need to be revised for approval. A revised information package must be submitted for approval.
- 3) Not Approved. The Technical Project Manager does not concur with the submitted details. The design shall be modified and resubmitted in its amended form.

The Authority will disposition drawings and other documentation / submittals as "Approved," "Conditionally Approved," "Not Approved," or "Approval Not Required" (with the required changes noted) within one (1) month after acknowledged receipt. The Authority will respond to an address within the United States designated by the Contractor. If more than one drawing is submitted at a time, the drawings shall be listed in the transmittal according to numerical drawing sequence.

Drawings and other documentation / submittals shall be submitted in an orderly and logical sequence to enable the review of interfaces and relationships between all major elements and subassemblies. As agreed by the Authority and the Contractor, the Contractor may submit a limited number of drawings for approval during a specified time period (e.g., weekly, biweekly, or monthly).

In cases where the Contractor's drawings have been either "Not Approved" or "Conditionally Approved," the Contractor will not receive a delivery date extension.